

FLOOD WARNING SYSTEM DEFICIENCIES AND RECOMMENDATIONS FOR THE DELAWARE RIVER BASIN

Members of the FAC, which includes technical experts responsible for the design and operation of the Delaware River Basin's flood warning system, have identified both site-specific and system-wide deficiencies. The deficiencies have been developed from a basin-wide perspective. Site-specific deficiencies relate to immediate needs and the recommendations are intended to remedy known equipment deficiencies in the current day to day operations of the basin-wide river flood warning network. These recommendations focus on river flood warning, where lead time can be improved by equipment upgrades. The system-wide deficiencies and associated recommendations relate to needs for inventory, evaluation, and modernization to take advantage of improved technology. These recommendations are intended to begin the modernization of both the river and flash flood warning systems. The inventory work may identify additional site specific needs for gages and telemetry that are not included here. The benefits of the recommended equipment upgrades extend to other areas of water resources management. The cost estimates for the recommended work are preliminary. A map showing the general location of the recommended improvements is shown on Attachment B.

Site-specific Deficiencies and Recommendations

- S-1 Deficiency: The real time rain gage network used by the NWS in the New York State portion of the Upper Delaware River watershed is inadequate. Gages should be added to the network in Delaware, Sullivan, and Ulster Counties.
- Recommendation: The real time rain gage network used by the NWS in the New York portion of the upper Delaware River Basin should be expanded as follows:
- C Install the telemetry and upgrades required to add six rain gages owned and used by the NYCDEP upstream of the NYC reservoirs to the network used by NWS.
 - C Add six additional real time rain gages in Delaware, Sullivan, and Ulster Counties, NY at selected sites.
- Estimated Cost \$ 207,000 One-time \$ 42,100 O&M
- S-2 Deficiency: The number and location of flood forecast points in the vicinity of the New York City reservoirs is inadequate for flood forecasting by NWS. Forecast points should be established for the West Branch of the Delaware River at Walton, NY, the East Branch of the Delaware at Margaretville, NY, and Dry Brook at Arkville, NY.
- Recommendation: Install and maintain telemetry upgrades to establish flood forecast points at the following stream gages in the vicinity of the NYC reservoirs. This area experienced record flooding in 1996 and river flood warning is inadequate.
- C West Branch Delaware River at Walton, NY
 - C East Branch Delaware River at Margaretville, NY
 - C Dry Brook at Arkville, NY
- Estimated Cost \$ 46,500 One-time \$ 9,330 O&M
- S-3 Deficiency: There is an inadequate number of volunteer rain and snow spotter stations in Pike County, PA and Sullivan County, NY.

Recommendation: Use the newly established NOAA Weather Radio station in Hardyston, Sussex County, NJ and the existing transmitter at Binghamton, NY, to broadcast the need for volunteer rainfall and snow spotters in Pike and Sullivan Counties, NY. Minimal Cost.

S-4 Deficiency: There is currently no flood forecast point for the Neversink River in the Port Jervis vicinity.

Recommendation: Re-establish the USGS gaging station for the Neversink River at Godeffroy, NY, equip the station with real time telemetry, and establish the gage as a flood forecast point to provide warning for residents of Port Jervis, NY.

Estimated Cost: \$ 15,500 One-time \$ 3,110 O&M

S-5 Deficiency: The stream gage for the West Branch of the Delaware River at Stilesville, NY, at the outlet of Cannonsville Reservoir, is not equipped with satellite telemetry for real time access by the NWS. Funding for continued operation and maintenance for the newly installed telemetry at the stream gage for the Delaware River at Barryville is required.

Recommendation: Equip the stream gage on the West Branch of the Delaware River at Stilesville, NY with a data collection platform and satellite telemetry. Maintain satellite telemetry for the Delaware River at Barryville.

Estimated Cost: \$ 15,500 One-time \$ 6,220 O&M

S-6 Deficiency: The gage height at which flooding begins (flood stage) has not been established for a significant number of the basin's stream gages. This is a pre-requisite for establishing a flood forecast point at a given gage. One page graphics illustrating flood stage vs. flood impacts - designated as E-19 impact statements by NWS - also need to be established for these gages. These gages are located throughout the basin.

Recommendation: As part of the application of the AHPS program in the Delaware River Basin, establish flood stages and E-19 Impact statements for potential flood forecast points where gaging stations are equipped with real time telemetry. It is estimated that there are approximately 35 such gages distributed throughout the basin. The benefits of these stations would be extended by establishing flood stages which could be accessible through the Internet. Coordination between the NWS and local officials would be required to establish the flood stages.

Estimated Cost: \$ 70,000 One-time \$ 5,000 O&M

S-7 Deficiency: The NWS now uses telephone lines to contact stream gages in northern Delaware to obtain stream stage data. The addition of satellite telemetry would provide quicker access

as well as backup communication if telephone service is disrupted. The flood forecasting network in northern Delaware would also be improved by the re-activation of the stream gage on Mill Creek near Hockessin, Delaware.

Recommendation: Add satellite telemetry to seven stream gages in New Castle County, Delaware including those used as flood forecast points and equipped with telephone telemetry, and including those on Shellpot Creek and the proposed re-activated gage on Mill Creek at Hockessin, Del.

Estimated Cost:	\$ 108,500 One-time	\$ 31,160 O&M
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S-8

Deficiency: Stream gages in two urbanizing southern New Jersey watersheds– Little Ease Run near Clayton, and South Branch Pennsauken Creek at Cherry Hill - are not equipped with satellite telemetry. Telemetry at these locations would provide near real time information to the National Weather Service for improved flood forecasting. The gages are Little Ease Run near Clayton, NJ and South Branch Pennsauken Creek at Cherry Hill, NJ.

Recommendation: Install and maintain satellite telemetry at Little Ease Run near Clayton, NJ and South Branch Pennsauken Creek at Cherry Hill, NJ.

Estimated Cost:	\$31,000 One-Time	\$6,220 O&M
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Total Estimated Cost for Site-Specific Recommendations:

\$ 494,000 One-time	\$ 103,140 O&M
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General Deficiencies and Recommendations

Recommendations G-1 through G-3 are necessary as inventory and evaluation steps.

G-1

Deficiency: There is no comprehensive inventory of the precipitation instrumentation now available for the basin. A portion of the available instrumentation is not owned, operated or used by the NWS. Inventory and analysis of the gages is needed to determine the improvements required in order to make the maximum use of existing equipment to improve the flood warning network. For example, the USGS and City of New York operate rain gages which are not part of the NWS network. The inventory work would permit evaluation of the gages for their adequacy for river flood warning as well as their use with Doppler Radar for flash flood warning.

Recommendation: A comprehensive inventory of all available precipitation gages in the Delaware River Basin should be developed using GIS. Information listing automated gages, volunteer monitoring gages, and gages used for school programs is required. This work requires inputs from all gage owners and creation of GIS coverages and attribute files. The purpose of the inventory is to provide the information necessary to evaluate the existing precipitation network and potential improvements.

Estimated Cost:	\$20,000 One-time
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G-2

Deficiency: An evaluation of the adequacy of the existing basin-wide precipitation network is needed in order to make the most efficient use of existing gages.

Recommendation: Precipitation gages not used by the NWS in its flood forecasting work need to be evaluated to determine if they can and should be added to the existing river flood warning system, and for use with Doppler Radar for flash flood warning. The evaluation should include an analysis of subbasins and the adequacy of the precipitation gages in each. The evaluation should determine:

- C The location of additional gages required to improve the flood warning network relative to flood risk.
- C The existing non-NWS gages that can be incorporated into the NWS network.
- C The upgrades required to make existing non-NWS gages compatible with NWS requirements where the gages are to be added to the network

Upon completion of this evaluation, recommendations would be made on upgrades as well as locations and costs for additional new precipitation gages.

Estimated Cost

\$30,000 One-time

G-3

Deficiency: The basin's flood forecast points require evaluation based on their adequacy for river flood warning and the potential for downstream flood damage.

Recommendation: The basin's flood forecast points should be evaluated against their adequacy for river flood warning and potential downstream flood damage. The evaluation should include an analysis of subbasins and the adequacy of the flood forecast points in each. Based on this evaluation, a determination should be made as to which existing stream gages, not now used as flood forecast points, should be upgraded for this purpose, and where additional gages are needed.

Note: As an example of the need for this evaluation, stream gages in the Delaware River Basin have been discontinued due to lack of funding, but have the potential to be re-activated and equipped with telemetry. This would be more economical than establishing new gages. There are also active stream gages which could be equipped with satellite telemetry for possible inclusion as flood forecast points.

Estimated Cost:

\$30,000 One-time

G-4

Deficiency: Local knowledge of the meaning of forecast flood stages is strong in some areas of the basin and weak in others. There is a need to improve this through work with local officials and the public. Additionally, the public's access to flood warning information needs to be improved, along with understanding of the importance of stream gages.

Recommendation: A coordinated flood warning education and outreach program should be established for the Delaware River Basin. The program should include information on how the flood warning system works, how river flood warning and flash flood warning information can be obtained, and the importance of local knowledge of the meaning of flood stages. The program should include information about the multiple benefits of stream gages and the need to continuously fund the operation and maintenance of these gages. Encouraging and identifying potential cost sharing opportunities should be part of this effort.

The program should combine information prepared by the NWS, Corps of Engineers, and state and federal Emergency Management Agencies. Information on flood warning assistance opportunities for communities should be readily available. Press releases and conferences can be coordinated through the DRBC Public Information Office. Brochures would be distributed at meetings, public information sessions, and to middle and high school science teachers. Efforts would be made to work with local officials to provide improved knowledge of flood stages and interpretation of flood forecasts.

Estimated Cost: \$50,000 annual

G-5

Deficiency: Much flood damage occurs in headwater and urbanized areas, away from the major rivers. There is a need to develop better means of flood and flash flood warning in headwater regions. Local , real time monitoring equipment such as radio rain gages and Doppler radar technology, and related software are required to implement improved flash flood warning.

Recommendation: The level of headwaters flood warning should be improved in the Delaware River Basin through application of the NWS's AHPS work to combine GIS and Doppler Radar technology. This approach is applicable to small watersheds (approximately 1.5 square miles). As illustrated by flood insurance claims data, significant flood damage occurs in headwater areas where flood warning lead time is extremely short. In most cases, only a generalized warning for portions of a county can be issued.

As part of the AHPS program, the NWS is combining GIS small watershed delineations with radar estimated precipitation and computer modeling to rapidly identify potential flooding. A prototype program was developed for the Pittsburgh, PA metropolitan area using a pre-existing set of GIS small watershed delineations and a set of rain gages for verification of the radar estimates. The NWS expects that the program will be expanded to cover all Doppler radar zones in the country by the end of 2001. Each weather service office will be provided with a product which indicates which watersheds will experience flooding based on Doppler rainfall estimates. The product will be updated with each radar sweep. The information will then be broadcast by the NWS forecast offices.

Graphical methods used to distribute the flash flood warnings to the county and local level have not yet been developed. It is recommended that prototype graphical product distribution be developed for urbanized portions of the Delaware River Basin. This will require work with the NWS, emergency managers, and potential local users to provide a product that is distributed in real time and quickly understood. This would provide local emergency managers with a real time image of where their resources should be concentrated to respond to the flooding. The work would be consistent with national efforts to implement the AHPS program.

The initial phase of this work would involve a prototype application to several urban, county sized sections of the Delaware River Basin that is prone to flash flooding, and would consist of the following.

- * Addition of Integrated Flood Warning and Observation Network (IFLOWS) rain gages, telemetry, and software to the existing precipitation network as necessary for verification of rainfall estimates.
- * Work with NWS and county and local emergency officials to develop graphical products for distributing flash flood information.

- * Provide equipment and software for distribution of graphical products.
- * Educate local emergency officials and coordinate with media on the use of Doppler Radar for estimating flooding potential and issuing warnings.

Estimated Costs for G-5 \$510,000 One Time \$10,000 annual

G-6

Deficiency: Additional flood warning technology improvements are being developed through the National Weather Service's AHPS program and Corps of Engineers GIS based flood stage forecast mapping work, but have not been applied in the Delaware River Basin. This technology should be extended to the basin to begin modernizing flood warning capabilities. This would be consistent with the national AHPS program. The effectiveness of flood stage forecast mapping at the local user level should be demonstrated on a prototype basis.

Recommendation: Application of the AHPS program would complement the site-specific monitoring improvements recommended earlier in this proposal and be consistent with national modernization efforts by the NWS. The program would entail the use of real time information and interactive mapping to make both short term and long term flood stage and flood inundation forecasts available in a graphical format for any stream gaging station. In addition to flood warning benefits, the long term forecasting component could better define expected reservoir inflow and enhance water supply planning during drought periods. An overview of some of the elements of AHPS is provided in Attachment A.

This proposal recommends initial application to 31 existing flood forecast points throughout the Delaware River Basin. Flood stage forecast mapping would initially focus on three flood damage centers along the main stem Delaware and Schuylkill Rivers for prototype application.

In addition to the flash flood warning work recommended under G-5, the additional steps require application of AHPS as follows for gages now equipped with satellite telemetry.

- Equip selected flood forecast point gages with web cameras.
- Application of flood forecast models. Initially, existing forecasting models could be used with probabilistic models phased in as they become available for stream reaches.
- Extend streamflow vs. stage rating curves at flood forecast points as necessary.
- Creation of a graphical interface that provides the basin's state emergency management systems and Internet users with an interactive map showing each gage. Linked information, in addition to the current flow and stage already available, would include:

- C 5-day stage forecast
- C Flood crest forecast and long range flood forecast if available
- C E-19 Flood Impact Statement
- C Real time web picture at gage site
- C Doppler radar rainfall estimate as available
- C Weather forecast

- Expand annual snow surveys to improve estimates of potential snowmelt contributions to flooding. The work would be carried out by incorporating data now collected by the City of New York and Corps of Engineers with overflights by the National Operational Remote Sensing Center.
- Develop prototype flood stage forecast mapping for priority damage centers along the Schuylkill and main stem Delaware Rivers. An example of flood stage forecast mapping is shown in Attachment A. An objective of the mapping would be provision of real time maps with automatic updating for each new flood forecast. Education of map users will be built into this program and usefulness of the products would be evaluated from the local perspective.

Estimated Costs for G-6: \$1,064,000 One-time \$ 131,040 Annual

Total Estimated Costs for the General Deficiency and Modernization Recommendations:

\$1,654,000 One-time \$191,040 annual

Grand Total Costs for Recommendations:

\$2,148,000 One-time \$294,180 annual/O&M

These recommendations will move the Delaware Basin in a direction that would capitalize on advances in flood forecasting. The program would be expanded to include additional flood forecast points based on results of the recommended evaluations. Additional flood stage forecast mapping would be completed if the prototype mapping proves useful at the local level.

This cost estimate does not include costs for the installation and O&M of additional precipitation gages and forecast points, telemetry upgrades, etc. recommended as a result of the inventories and evaluations nor does it include mapping beyond the prototype recommendations. Such additional costs would be based on the results of those inventories, and opportunities for cost sharing would be explored.

Potential For Cost Sharing To Support Gages

The preceding recommendations are based on deficiencies identified by organizations responsible for basin-wide river flood warning. Localized flood and flash flood problems exist throughout the Delaware River Basin. For example, Upper Providence Township, Montgomery County, has experienced repetitive flood damage along the Schuylkill River in the Port Providence and Montclare vicinities. Upper Providence Township has recently contacted a number of flood loss reduction organizations and is interested in obtaining assistance and in participating financially (cost sharing) in the development of an improved local flood warning system for their area. The township has been directed to the NWS and to the U.S. Army Corps of Engineers for local flash flood warning assistance, and have been in contact with FEMA and Montgomery County.

The willingness of local sponsors to cost share the installation and especially the operation and maintenance of gages has become critical to flood warning success, as well as to the use of gages for the many purposes other than flood warning. One of the goals of the outreach recommendation is to identify local interest in cost sharing as a means of adding to and maintaining the flood monitoring network.